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# EXPERIMENTS ON THE ADOPTION OF LASIUS, FORMICA AND POLYERGUS QUEENS BY COLONIES OF ALIEN SPECIES.<sup>1</sup>

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The experiments recorded in this paper were performed during the past summer in the laboratory of the Bussey Institution, Harvard University, at the suggestion and under the direction of Professor W. M. Wheeler. At the beginning of this particular series of experiments I had in mind only two species with which I intended to work, namely, *Aphaenogaster tennesseensis* and *Aphaenogaster fulva* with its subspecies *aquia* and variety *picea*, but a number of field excursions taken during July and August brought to hand several other species which served as such excellent material for similar experiments that it was decided to include them also.

## OBJECT OF EXPERIMENTS.

The object of these experiments was to determine whether the queens of certain species of ants are parasitic upon certain other species in founding their colonies. The various methods employed by queen ants in founding their colonies are stated in Wheeler's "The Founding of Colonies by Queen Ants," and since the following experiments have a direct bearing upon that question, and in fact form a continuation of exactly the same sort of work, I think I can do no better in the beginning than quote a few paragraphs from that paper.

"Female, or queen, ants in founding their colonies resort to one of three methods, which may be known as the usual or typical, the redundant, and the defective. . . .

I. "The female ant is able by herself alone to start her colony; that is, under favorable circumstances she can produce and bring to maturity the first brood of workers and thus insure the further growth and development of the colony. She is capable of passing many months without nourishment even while she is feeding her off-spring. Her voluminous fat-body, built up during her larval life in the maternal nest, together with her degenerating wing-muscles, furnish the sub-

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stances that are converted into food for the young. Although so arduous that few of the many queens of all that celebrate their nuptial flight during a season ever succeed in founding a colony, this method is, nevertheless, the one adopted by the great majority of ants."

The second method refers to the fungus-raising ants (Atti) and need not be given here.

"3. The female ant, owing to her small and delicate stature, or delayed fertility, is quite unable to found a colony without the aid of workers of another species. This method, which is resorted to by parasitic species—using that term in a very broad sense—appears under three different aspects.

"A. As temporary social parasitism. The female seeks and obtains adoption in a small queenless colony of another species and permits its alien workers to bring up her young. When these have matured, they emancipate themselves and become an independent colony, either by emigration or, more probably, only through the natural death of the host species."

"B. As permanent social parasitism. The female seeks and obtains adoption in a colony of some other species and there permanently resides together with her offspring. Examples: *Anergates*, *Strongylognathus*, *Protomognathus*, *Wheeleria*, etc.

"C. As dulosus, or slavery. The solitary female enters a small colony of another species, kills the workers, and seizes and rears the progeny (larvæ and pupæ) as a first step towards bringing up her young. The workers produced by the female subsequently make forays on other colonies of the host species and appropriate their offspring. While they use a portion of these as food they permit another portion to develop as 'auxiliaries' or 'slaves' so that the colony preserves its 'mixed' character."

In the same paper and in others Wheeler has also brought out the fact that parasitic species are sporadic in their occurrence, that they usually produce a very large number of females which are aberrant in some way, such as being of unusually small size, sometimes smaller than the workers, in being mimetic in coloration or behavior, in being covered with fulvous, myrmecophilous hairs, etc. Therefore the possession of the above characteristics to any extent by a species of ant is good grounds for believing that the queens of that species may be parasitic in founding their colonies.

A paragraph on page 447 of Wheeler's book, "Ants, their Structure, Development and Behavior," gives the reasons for performing adoption experiments with queens of *Aphænogaster tennesseensis*.

"The female of the myrmecine ant *Aphænogaster tennesseensis* in being deep red and of very small size, with a glabrous body and huge, flattened, epinotal spines protecting the vulnerable abdominal pedicel, is so unlike the females of any other members of the genus *Aphænogaster* that she was originally described by Mayr as the type of a distinct species (*A. levis*). These peculiarities suggest temporary parasitism and this is borne out by the observations of Schmitt

and myself (1901c). Schmitt found near Beatty, Pa., a small mixed colony of *A. tennesseensis* and *A. picea*, a variety of *fulva*, and one of the commonest ants in the northern states. He was impressed with the fact that the nest of this colony was under a stone, because *tennesseensis* normally nests only in rotting wood. During the summer of 1902 I found near Rockford, Ill., two mixed colonies like that observed by Schmitt, except that the variety *picea* was represented by the variety *rudis*. Both colonies were of small size and situated under stones. In one of them a *tennesseensis* queen was unearthed. There can be little doubt, therefore, that the glabrous queens seek out small nests of some variety of *fulva* and start their colonies in them just as *consocians* does in the nest of *incerta*. This habit is also indicated by the sporadic distribution of *tennesseensis* and its occurrence only in localities where some form of *fulva* is abundant."

The reasons for performing adoption experiments with queens of the other species will be given as I take up those experiments.

#### METHOD.

The method used in these experiments consisted in placing artificially dealated queens of the supposedly parasitic species in a nest with a few workers and brood of the supposed host species and observing their behavior under these conditions. This is the same method used by Wheeler in the experiments recorded in the paper mentioned above, and possible objections to it are answered by stating that an artificially dealated queen behaves in the same manner as a fertilized queen that has dealated herself, and that if one is to conduct such experiments on a large scale it is necessary to use artificial nests and to prevent the escape of the introduced queen. For most of the experiments I used large Petri dishes 4 1/2 and 6 in. in diameter into which I dumped the ants with their brood and some earth from the nest. For some of the experiments, however, I used nests of the Fielde pattern, and in that case I always introduced the queen into the light chamber and allowed her to find her own way into the dark chamber where most of the ants stayed, thus imitating natural conditions a little more closely. When I used Fielde nests, one chamber was kept covered with a piece of orange-colored glass. A few of the experiments with each species I watched very closely, especially when the queen was first introduced, sometimes watching a nest almost constantly for several hours, but as I had a large number of experiments going at the same time, sometimes more than fifty, I had to be content with examining most of them hastily several times a day and depending

chiefly upon the final result which, after all, is the important thing.

#### APHÆNOGASTER TENNESSEENSIS.

As this species does not occur in eastern Massachusetts I collected part of a large colony from a wood near Urbana, Ill., June 8 and brought it with me a few days later to the Bussey Institution, where I transferred the ants to a plaster of Paris nest, made on the Fielde pattern. The nest contained only workers and a large number of larvae. By the middle of July winged females began to appear and during the summer more than a hundred were produced. These, and a few sent me from Illinois later in the summer by Messrs. Hugh Glasgow and R. D. Glasgow, were the ones used in the experiments. Altogether I tried thirty-five queens of *A. tennesseensis* with eleven different colonies, two of which were *A. fulva* subspecies *aquia* var. *picea*, one *A. fulva*, and the others *A. fulva aquia*. The latter is probably more common where *A. tennesseensis* occurs. Of these thirty-five queens I got but one clear case of adoption and unfortunately this was with one of the colonies for which I have but scanty notes. The notes of this experiment are as follows:

#### EXPERIMENT B. 24c.

- Aug. 18.—3.00 P.M. I place an artificially dealated queen of *Aphænogaster tennesseensis* in a Petri dish with five workers and about fifty pupæ of *A. fulva aquia*.
- Aug. 19—9.00 A.M. Queen standing by herself.
- Aug. 20—9.30 A.M. The same.
- Aug. 21—11.30 A.M. She is standing on the pile of pupæ with the workers, none attacking her.
- Aug. 22. The same.
- Aug. 23—8.30 A.M. She stays in the midst of the workers and pupæ and seems to have been adopted.
- Aug. 23—3.30. Still with the workers—they never attack her.
- Aug. 24—8.00 A.M. In the center of the bunch of workers; about three dozen of the pupæ have become callows.
- Aug. 28. Still being treated as their own queen.
- Sept. 10. I have examined her every day up to the present time, and have never seen her treated by the workers other than as their own queen. There are now about sixty workers.

In all the experiments with *Aphænogaster tennesseensis* the queen was attacked by the workers, usually at the very outset, sometimes not until she had been in the nest for a few minutes.

Her behavior was about the same in most cases; she was timid and either ran away or crouched down in a supplicatory posture. Some of the queens, however, showed no fear whatever at first and approached the *fulva* workers as though they were members of the same colony. Constant biting and pulling about by the legs and antennæ, however, soon caused them to try to escape from their tormentors. In nearly every instance the behavior of the introduced queen was conciliatory and in no case did she at first seem to resent her harsh treatment but seemed to try either to conciliate the *fulva* workers or to escape from them. One queen, however, as will be shown in the following experiments, departed widely from what is apparently the normal behavior under such conditions by seizing a worker and carrying it about when the others attacked her. At first this behavior seemed to render her almost immune from further attacks and I began to think that perhaps only such queens as showed this particular phase of behavior succeeded in getting themselves adopted. Later on, however, the attacks were renewed and the queen was finally killed. I will give one experiment in detail as a type, and summarize the others.

## EXPERIMENT B. 18.

Aug. 9—9.00 A.M. I place an artificially dealated queen of *Aphenogaster tennesseensis* in the light chamber of a Fielde nest containing about two dozen workers and a small pile of larvæ and cocoons of *A. fulva aquia*. She goes at once into the dark chamber. The first few workers that she meets recognize her at once as a stranger, but do not attack her. Several threaten her and then pass on. After about five minutes one worker grabs her by the petiole and carries her about in the nest. She does not seem afraid and does not try to get away; her manner is conciliatory.

9.10 A.M. She goes out into the light chamber but soon returns.

9.20 A.M. One worker is tugging at her antennæ.

9.25 A.M. The same worker is still holding her.

9.27 A.M. She gets free from the worker and runs around in the dark chamber. Many of the ants she meets do not attempt to attack her.

9.30 A.M. Another worker catches her by an antenna and holds her for a while.

9.44 A.M. Two workers lick her for about two minutes and then go away.

9.47 A.M. A worker seizes her by one of her tarsi and pulls her about for a while.

9.48 A.M. Three workers are licking her. She is resting on the sponge about one half an inch from the brood. A number of workers keep passing by her; some of them stop and lick her a while, some feel her over with their antennæ, open their mandibles as though to attack her and then go away without doing so. Sometimes she pats the heads of the workers with her antennæ as though begging food.

- 10.09 A.M. One worker catches her by a middle leg and pulls her about for a minute, then stops and licks her thorax and abdomen, then seizes her again by the leg and pulls her, but apparently not very hard. Again it stops and licks the queen for a minute and then goes a little to one side and begins cleaning its own antennæ but soon comes back to the queen and repeats the whole performance. The worker keeps this up for twelve minutes and then goes away. The queen has remained all this time in the same position, one half inch from the brood.
- 2.00 P.M. She is out in the light chamber but soon goes back.
- 4.35 P.M. One ant holding her by the petiole, another by one antenna.
- 6.00 P.M. A worker holding her by the antennæ.
- 8.15 P.M. The same.
- Aug. 10—7.15 A.M. She is out in the light chamber alone.
- 9.15 A.M. She is in the dark chamber but not with the workers.
- 11.30 A.M. She has been in the light chamber by herself most of the morning.
- 11.50 A.M. Two workers are pulling her about.
- 2.00 P.M. She is running around in the light chamber, trying to get out. The workers seem more hostile today than yesterday.
- Aug. 11—8.00 A.M. The queen is dead; I remove her.
- 9.05 A.M. I place another queen in the light chamber. She starts into the dark chamber and is seized in the passage way by two of the workers, one pulling an antenna, another holding her petiole. They drag her about in the dark chamber.
- 9.50 A.M. The queen is on the sponge near the brood and has seized the petiole of one of the workers in her mandibles. Workers are standing about but do not attack her; once in a while a worker licks her.
- 10.30 A.M. A worker seizes her by the hind tarsus and holds her for five minutes. She is still holding the worker.
- 10.15 A.M. Still in the same place. She is straddling the head and thorax of the worker which she is holding by the petiole. Once in a while a worker seizes her by a leg or an antenna, but some of the workers are licking her.
- 10.30 A.M. Still holding the worker.
- 11.10 A.M. The same.
- 12.10 P.M. The same.
- 1.30 P.M. The same. She is standing in the midst of the brood.
- 3.50 P.M. Still holding the worker; she is carrying it around now on the sponge and in the midst of the other workers and brood. She pays no attention to the other workers, some of which nab her at times. There is no excitement in the nest.
- 4.30 P.M. Still carrying the worker around; she does not get far from the sponge and most of the time is on it with the brood and workers. The worker seems to be nearly dead and for several hours has made no effort to escape or defend itself.
- 5.00 P.M. The same.
- 6.00 P.M. The same. A worker holding the queen by the antennæ.
- 8.00 P.M. The queen is still on the sponge holding the worker.
- 9.00 P.M. She is about two inches from the sponge, a worker holding her by the antennæ; she is not holding the worker now.
- Aug. 12—8.00 A.M. She is again on the sponge with the brood, a worker tugging at one of her tarsi.

- 9.00 A.M. She is about two inches from the sponge, not holding the worker, but one of them is holding her by the antennæ.
- 9.15 A.M. She is again on the sponge with the brood and is holding the worker by a middle leg. The worker seems to be helpless in her grasp and does not attempt to escape.
- 9.22 A.M. I change the orange glass in order to make the other chamber the dark one.
- 9.35 A.M. The brood has all been removed to the moist sponge in the other chamber. A few ants still running about in this (now light) chamber. The queen and her victim still on the sponge. The other ants sometimes come up and feel them over with their antennæ but do not attack the queen.
- 10.00 A.M. During the past forty-five minutes the queen has been standing almost motionless. She now begins to move about on the sponge, probably because all the other ants are gone. At times she stands on her middle and hind feet and with her front feet seems to try to twist or change the position of the worker she is holding. She bends under her abdomen as though spraying the worker with formic acid.
- 10.10 A.M. She leaves the sponge and carries the worker about for a minute and then comes back.
- 11.30 A.M. She has remained on the sponge all this time holding the worker.
- 11.40 A.M. She is alone on the sponge. I do not know whether the worker escaped or whether it died and she dropped it. There are several dead workers in this chamber.
- 11.45 A.M. She is running about in the light chamber and seems to be entirely uninjured.
- 11.50 A.M. She goes into the dark chamber, seizes a worker by the thorax near the petiole (almost exactly the same hold she had on the first worker) climbs on to the sponge and stops just in the middle of the brood and workers some of which pull her legs or antennæ, but she retains her hold on the one worker and remains in the same position. I remove all the dead workers from the nest.
- 1.40 P.M. Still holding the worker in the same way.
- 3.15 P.M. The queen is still holding the worker and is staying with the brood.
- 6.15 P.M. The same.
- Aug. 13—9.15 A.M. The same. There are no dead workers in the nest so she has not killed any of them.
- 11.00 A.M. The same.
- 12.00 M. The same.
- 1.25 P.M. The queen is not holding the worker but three of the workers are holding her, one by the petiole, one by an antenna and one by a mouth part.
- 3.00 P.M. Three workers are holding the queen.
- 6.00 P.M. The queen is again holding a worker and three workers are holding her.
- Aug. 14—9.30 A.M. The queen is being stretched out by two workers that are pulling in opposite directions on her legs. She is not holding the worker now.
- 10.30 A.M. The queen is running about in the light chamber.
- 6.00 P.M. She is alone in the light chamber, and has two legs and one antenna partly gone.
- Aug. 15—9.00 A.M. In the light chamber alone; she has four legs and both antennæ partly gone.



- 1.50 P.M. The same.  
3.50 P.M. The queen is dead and dismembered.  
Aug. 16—8.15 A.M. I place in another queen. She runs about in the nest avoiding at first the workers who threaten her. After about four minutes when she is resting on the sponge (not with the brood), a worker comes up and begins licking her at once and continues doing so for more than five minutes.  
8.45 A.M. The queen is in the corner of the nest feigning death. I thought she was dead at first; several workers standing around her.  
9.00 A.M. She gets up and goes over to the brood; after a few minutes a worker drags her away.  
9.30 A.M. Three workers holding her.  
12.00 M. They are still attacking her.  
3.00 P.M. She is being stretched out by four workers.  
6.00 P.M. The same.  
Aug. 17—7.30 A.M. Three workers are holding her. One leg partly gone.  
5.30 P.M. The queen is dead and dismembered.  
On August 19 I placed in another queen. She received the same treatment and was killed by August 24. On August 25 I placed in another. This one fared a little better and lived until September 8.

This colony, it will be seen, killed in succession five queens of *Aphænogaster tennesseensis* between August 6 and September 8. That there is a tendency toward adoption is seen in the fact that a number of the workers often licked the queen just as they would their own, while others were attacking her. It seems as though there is something about the queen that is attractive to the workers while at the same time the odor of a different species antagonizes them. In nature the specific odor is probably not so distinct by the time the *tennesseensis* queen enters a *fulva* nest since she will have been out of the parent nest and running about on the ground for some little time. In this and in other adoption experiments only a few ants attacked a queen at once, usually not more than two or three, and very seldom more than five or six, even when the colony was a very large one. It would seem as though the other ants realized that the intruder was being taken care of.

The variety *picea* seemed to be more hostile to the *tennesseensis* queen than *aquia*, but even here a tendency toward adoption is shown, as may be seen from the treatment accorded one of the queens in an experiment from which I take a few notes. This colony contained seventeen workers and a small pile of larvæ of *Aphænogaster picea* and were in a small two-chambered Santschi nest made of glass and plaster of Paris.

July 25—2.45 P.M. I place in the first queen. She receives very harsh treatment and is killed by 4.00 P.M. and her body cut in two at the petiole.

4.10 P.M. I place in a winged queen. She receives no better treatment than her predecessor and is killed by 6.00 P.M.

July 27—9.15 A.M. I place in the light chamber another artificially dealated queen of *Aphænogaster tennesseensis*. She runs about in the light chamber for several minutes, goes into the passage-way several times but not into the dark chamber. The *fulva* workers evidently detect her by her odor and one or two enter the light chamber and dart at her with abdomen turned under as though to grab her, but simply feel of her with their antennæ and allow her to run away.

9.45 A.M. Still in the light chamber.

4.45 P.M. I was compelled to be away during the day. The queen is now resting on the brood and is not being molested by the workers. One worker is licking her, although at times it seems to nab her.

5.30 P.M. The queen is licking the *fulva* larvæ. She moves about among the workers, none of which now molest her in the least. The pieces of the other two queens have been distributed among the larvæ and are being eaten by them.

July 27—8.00 P.M. The queen is resting on the larvæ with the workers and appears to be perfectly at home.

July 28—7.45 A.M. The queen is resting contentedly with the workers and larvæ. I was compelled to leave the experiment for a few days but during my absence one of the students in the laboratory recorded that on July 28—3.00 P.M. hostilities were again begun against the queen and that she was killed by 9.00 A.M. July 31.

Between August 2 and August 26 I placed in the nest in succession seven more queens of *Aphænogaster tennesseensis*, all of which were killed after a longer or shorter time.

The other colony of *Aphænogaster picea* which I used contained about forty workers, one queen, and a number of larvæ and pupæ. I placed the first queen in the nest on July 19 at 2.10 P.M. She was killed some time during the following night.

July 20—8.55 A.M. I place in another queen. She lives until 10.45 the next day. At 10.50 A.M. I place in a third queen and she succeeds in living until the morning of July 23. I also tried two queens of *Aphænogaster tennesseensis* with about twenty workers and some brood of the true *A. fulva*. Both queens were killed. The other experiments with colonies of *A. aquia* may be briefly summarized as follows:

#### B. 24a.

Contained ten workers, two winged queens, one male and brood. Between August 18 and September 1, I placed in three queens all of which were killed.

#### B. 24b.

Contained eight workers and a few pupæ. Between August 18 and September 7 two queens were killed.

## B. 24d.

Contained eight workers and a number of pupæ. I placed in a queen August 29, which lived until September 4.

## B. 24e.

Contained seven workers and a number of pupæ. I placed in a queen August 30 and it lived until September 4.

One other experiment with a queen of *Aphænogaster tennesseensis* consisted in placing a dealated queen in a Petri dish with about thirty pupæ of *A. aquia*. The pupæ of this species, as with other species of myrmicine ants, are naked and do not require the assistance of workers in hatching. They were collected and placed in a Petri dish with the queen July 23. The queen paid no attention to them whatever. In a few days the first callows began to hatch and busied themselves taking care of the remaining pupæ. The queen at first paid no more attention to the callows than she had to the pupæ and in fact stayed in another part of the nest most of the time. After about a half a dozen had hatched, however, she began to stay with them more of the time. The callows were not hostile to her but readily adopted her as their queen. This, however, is what was to be expected because of the discovery made by Miss Fielde and recorded in her paper "Artificial Mixed Nests of Ants." She says: "If one or more individuals of each species that is to be represented in the future mixed nest be sequestered within twelve hours after hatching and each ant so sequestered touch all the others with its antennæ during the ensuing days, these ants will live amicably together thereafter although they be of different colonies, varieties, species, genera or subfamilies." At the present time, September 10, all the pupæ have hatched and have become adult workers, about thirty in all, and are clustered about the *tennesseensis* queen exactly as though she were their own.

## FORMICA OBSCURIVENTRIS.

This subspecies of *rufa* occurs throughout the northern states east of the Mississippi River. It is fairly common in eastern Massachusetts and has been taken in Illinois. The queens are large, about the size of those of *F. sanguinea* var. *rubicunda*, and have shiny, jet-black abdomens with very little, almost no pubescence. The thorax and head are a darker red than in *F. sanguinea rubicunda*. The workers vary greatly in size.

There are no published accounts of the occurrence of this species in mixed nests in this country, but Professor Wheeler found such a nest this last spring near Boston, and has kindly given me permission to use the note which he made of it at the time. "April 10, 1910. On the northern slope of Great Blue Hill, under a stone, I found a mixed colony consisting of a dealated queen and about 80 workers of *Formica obscuriventris* with about 100 workers of *F. subsericea*. There were a few larvæ evidently of the former species in the nest."

On a trip to that same locality with Professor Wheeler, August 17 we came across a very large colony of this species which extended under several good sized stones from which we secured 10 dealated or partially dealated queens. The fact that they had been partially dealated indicates that they had probably been fertilized and readopted by the colony. The particular slope upon which this nest was found was very rich in nests of *F. subsericea*. I brought the queens of *F. obscuriventris* to the laboratory and also a large number of workers and brood from a colony of *F. subsericea*.

I divided the *subsericea* colony into five groups of workers and brood and tried one or more of the *obscuriventris* queens with each group. The behavior on the part of the queen and workers was the same in each case. Some of the workers attacked the queen, some began at once to lick her and others alternated between licking and biting her. The queen always seemed to show surprise at receiving such harsh treatment so different from what she was accustomed to receiving from the workers in her own nest. Then she would try to get away and finding that impossible would turn and bite a worker, sometimes producing a wound that caused death. If the *subsericea* colony was a large one the queen was soon killed, but in the smaller colonies the workers, after a time, ceased their attacks and began to tolerate her presence in the nest, while more and more of them began to treat her as their own queen. I will give full notes on one experiment which shows the difference in results attained in using large and small colonies.

B. 22b.

August 18—11.30 A.M. I place a queen (I think the mother queen from the colony) of *Formica obscuriventris* in light chamber of a Fielde nest containing

- about 75 workers, one male and many pupæ of *F. subsericea*. These *subsericea* are all very large individuals.
- The workers attack her fiercely when she is in the passageway. Some pull her toward the dark chamber while some pull the other way. They finally get her into the dark chamber where six or seven attack her at once.
- 12.00 M. She is in the dark chamber, workers still attacking her.
- 1.30 P.M. She is on the sponge in the dark chamber and is motionless. One worker is holding her by a middle leg, three others are licking her.
- 1.35 P.M. The one worker has let go her hold and four others are licking her. She seems to be dead.
- 2.30 P.M. The queen is dead. I change the light so as to make the other chamber the dark one.
- 4.00 P.M. They have moved the dead queen and the pupæ into the other chamber. I change the light again.
- 4.30 P.M. They again move the dead queen. I change the light again and when about two thirds of the workers are in the other chamber I block the passageway, leaving about two dozen workers, the dead queen and most of the pupæ on one side. I then place in another *obscuriventris* queen with these. They attack her also.
- 4.45 P.M. Two workers are holding her by the legs and two are licking her.
- 6.00 P.M. Four workers are holding her by the legs.
- August 19—8.20 A.M. Two workers holding her, one by a leg and one by an antenna.
- 11.45 A.M. Two workers holding her.
- 2.15 P.M. The two workers still holding her.
- 3.00 P.M. The queen is dead. I remove the plug and let all but twelve of the workers escape into the other chamber and then replace the plug.
- 3.50 P.M. I place in another queen with the twelve workers; they attack her. She does not attempt to bite them except when a worker gives her an unusually painful jerk or bite.
- 4.00 P.M. One worker is licking her and one holding her.
- August 20—8.00 A.M. One worker holding her by the leg.
- 2.00 P.M. Three workers standing near her; none holding her.
- 6.00 P.M. Two workers holding her.
- August 21—11.00 A.M. The queen is standing alone.
- August 22—11.00 A.M. She is standing with three workers; they do not attack her.
- 5.30 P.M. Two workers holding her.
- August 23—9.00 A.M. Not attacking her this morning; two workers staying with her.
- 2.00 P.M. Still standing with two of the workers.

Sept. 10. I have examined this nest several times every day since August 23 and have never seen the queen attacked. There are now ten workers and a number of larvæ and pupæ in the nest, and the queen stays with them all the time exactly as though she were their own.

The other experiments with queens of *F. obscuriventris* may be summarized as follows:

## B. 22a.

August 18. I placed an *obscuriventris* queen in a Petri dish with eight workers and some pupæ of *F. subsericea*. The workers at first attacked her and continued doing so at intervals until noon the next day. After that they did not attack her, but tolerated her presence in the nest and she remained standing by herself until noon August 23. After that she stayed with the workers all the time and was treated as their own queen.

## B. 22c.

August 19. I placed an *obscuriventris* queen in a Petri dish with eight workers and twelve pupæ of *F. subsericea*. She was attacked at first just as the others were and the workers remained hostile until about the middle of the following day when they became indifferent to her presence and by August 25 they adopted her and treated her as their own queen. She had received an injury however in the first attacks from which she did not recover and by the morning of August 27 was dead. There were then six workers in the nest and one of them seemed weak. I removed the dead queen and placed in another. I did not see her attacked after the first day and by a day or two later she was fully adopted by the five workers, the other one having died.

## B. 22d.

August 24. I placed an *obscuriventris* queen in a nest containing about fifty workers, one male and many naked pupæ of *F. subsericea*. She was vigorously attacked, but within five minutes after she was placed in, while four workers were holding her, two others were diligently licking her thorax and abdomen. There were too many hostile workers in the nest however and by the following morning she had been killed and beheaded.

## B. 22e.

August 29—4.00 P.M. I placed an *obscuriventris* queen in a Petri dish with ten workers and eight pupæ of *F. subsericea*. She was attacked by the workers that afternoon, but on the following morning was standing by herself on the opposite side of the dish from where the *subsericea* were with their pupæ, and remained thus for two days. On the third day I disturbed the nest a little, and she moved over and mingled with the workers. They did not attack her and from then on, she stayed with them most of the time and is now, September 10, fully adopted.

It will be seen in the above experiments that of the 8 queens of *F. obscuriventris* tried with workers of *F. subsericea*, 5 were adopted, that these 5 were with colonies of from 8 to 12 workers and that those that were not adopted were with colonies of from 25 to 75 workers. The ease with which these queens are adopted in small colonies of *subsericea*, the decided tendency on the part of many of the workers, even in the large colonies, to begin licking and caressing the queens almost from the first, the inquilinous tendency shown in the behavior of the queens themselves and especially the finding of the mixed colony mentioned in the note

above, give conclusive evidence of the fact that the queens of *F. obscuriventris* are, at least in part, temporary parasites on *F. subsericea*, and the fact that a number of partly dealated and therefore probably fertilized queens had been retained in the large colony may be taken as an indication that, once formed, the colony may grow by budding as is the case with the large mound ant, *F. exsectoides*, which has also been shown (Wheeler, 1906) to be temporarily parasitic upon *F. subsericea*.

#### LASIUS (ACANTHOMYOPS) LATIPES.

This species not only possesses aberrant females but is peculiar in the fact that it has two distinct forms of females as shown in a paper by Wheeler and McClendon, "Dimorphic Queens in an American Ant." These two queens have been designated by them as alpha and beta, the beta being the more aberrant but the more common, and up to the time of the appearance of the above mentioned paper, the only one known. The alpha queen, as shown by measurements given in that paper, is almost exactly intermediate between the beta female and the normal female of *L. claviger*. The two more probable of the four possible hypotheses suggested therein in explanation of the occurrence of these two forms are

1. That the dimorphism may be regarded as the result of hybridism between *L. claviger* and *L. latipes*.

2. That it may be a case of true dimorphism in the female sex.

In a recent paper, "An Aberrant *Lasius* from Japan"<sup>1</sup> Wheeler, after stating that he had made many observations in the field which showed that the queens of the following species of *Lasius*, *L. americanus*, *L. neoniger*, *L. nearcticus*, *L. brevicornis*, *L. (Acanthomyops) claviger* and *L. (Acanthomyops) interjectus* are able to establish their colonies independently, adds: "But I have never seen any of the females of our *umbratus* forms (*mixtus* var. *aphidicola* Walsh, *subumbratus* Viereck, *minutus* Emery and *speculiventris* Emery) in the act of founding their colonies independently, and it is quite probable that they are temporary parasites on the extremely common *L. americanus*. Equally negative have been my observations upon *L. (A.) latipes* which

<sup>1</sup> BIOLOGICAL BULLETIN, 1910.

has the alpha and beta females. . . . That this species is a temporary parasite on *L. americanus* is indicated by the fact that near Colebrook, Conn., I found four small mixed colonies." The four mixed colonies mentioned here are the only ones of which there is any published account, but Professor Wheeler found another such colony this last spring and has given me the following note which he made at the time.

"Ellisville, Mass., April 21, 1910 Found a large mixed colony of *L. americanus* and *Acanthomyops latipes*, both about equally numerous and the *latipes* were no larger than the *americanus*. The nest was under a stone and contained a number of larvæ so young that I could not tell to which species they belonged. Both species took part in carrying the larvæ to a place of safety when the stone was raised, but the *latipes* were much more active in this pursuit than the *americanus*. The members of the two colonies were on the most friendly terms and occupied the same burrows."

The above facts furnished very good reasons for trying *latipes* queens with other species of *Lasius* and especially with *L. americanus*. On a field trip with Professor Wheeler in the Litchfield Hills near Colebrook, Conn., we came across a very large colony of *L. latipes* under a stone from which I obtained more than 75 winged females, all but 3 of which were beta females. These, and a number collected about two weeks later by Professor Wheeler, part of them from a colony in the same locality and part of them found crawling over the ground near Canton, Conn., after they had descended from their nuptial flight, were the ones used in the experiment.

Altogether I tried 79 queens of *L. latipes* with 28 different colonies of 8 different species of *Lasius* divided as follows: 14 colonies of *L. americanus*, 4 colonies of *L. nearcticus*, 4 colonies of *L. claviger*, 1 colony of *L. claviger* var. *subglaber*, 1 colony of *L. brevicornis*, 2 colonies of *L. interjectus*, 1 colony of *L. umbratus* var. *minutus* and 1 other colony of *L. latipes*. Out of all these I got but two clear cases of adoption in which the queen lived, one of these being an alpha, the other a beta female. However, not nearly all the deaths among the queens experimented with were due to the hostilities of the other ants, for the queens of



this species do not keep well in confinement and during the time the experiment was running more than 100 females not used in experiments died, part of them in the colony with their own workers and part of them in a nest by themselves. I am quite sure that at least four or five and probably more of the queens with *L. americanus* were already adopted or would have been adopted had they not died. In the majority of cases when I removed the dead queen I was unable to find any trace of injury whatever although in a number of cases the body was dismembered and sometimes eaten.

The most noticeable feature about the behavior of the *latipes* female when placed in with a small colony of workers was her desire to be with the brood, although in only one case out of all 79 did I see a queen pick up a larva or cocoon. This queen was in a Petri dish with a few workers of *L. nearcticus* and once when I uncovered the dish she picked up a cocoon and carried it around in her mandibles for about a minute. The queen was always attacked, and in the larger colonies of *americanus* and in the one of *L. umbratus minutus*, very fiercely. I did not see her in any case attempt to defend herself. In the larger colonies she only tried to get away and in the smaller colonies she usually got on the pile of cocoons, while the little workers attacked her and crawled over her large body in their efforts to kill her. Time and again when they succeeded in dragging her away she would return and mount the pile of cocoons. The callows hatching under these conditions would not, of course, be hostile to her and as at this time of the year the callows were emerging in large numbers there would soon be many workers about her that would accept her as their own queen. Even in the larger colonies a number of workers could often be seen licking the queen while others were attacking her. I will give a few notes on the colonies in which the adopted queens lived, and summarize the others.

B. 19/8 August 9. I place a beta queen of *L. latipes* in Petri dish with twelve workers of *L. americanus* and 150 cocoons.

Aug. 10. The queen is dead.

Aug. 11. I place in another.

Aug. 12. She is on the pile of cocoons with a large number of newly hatched workers.

Aug. 13. Still resting on the cocoons with the callows.

- Aug. 14. The queen and callows are clustered together on the brood.
- Aug. 15. The queen is almost hidden from sight by the workers that are clustered about her and over her. They are all resting on the pile of cocoons.
- Aug. 16. The same.
- Aug. 17. The same. Many of the workers licking her.
- Aug. 18. She is entirely hidden by the workers clustered over her. I have examined this nest every day up to the present time, September 12, and the workers have always been clustered about her. This is much more pronounced than is the case even with the rightful queen in a colony of *americanus*. There are now more than 100 workers in the nest.
- B. 19/13 Aug. 10. I place a beta queen of *L. latipes* in Petri dish with 30 workers and about the same number of cocoons of *L. interjectus*.
- Aug. 11. Dead. I place in another alpha queen.
- Aug. 12. She is staying with the workers on the pile of cocoons and seems to be perfectly at home.
- Aug. 13—9.00 A.M. She is near the pile of cocoons with a bunch of workers. I watch them for 30 minutes this morning and do not see the workers show the slightest sign of hostility although they are touching her and climbing over her all the time.
- 6.00 P.M. The workers are licking the queen with every evidence of satisfaction.

I have examined this colony every day up to the present time, September 12, and the behavior on the part of both the queen and the workers has always been the same.

In the following experiments not more than one *L. latipes* queen was in a colony at the same time, and although in the summary I make the statement that the queens were killed it should be remembered that probably the majority of them would have died even if they had been in artificial nests with their own workers since more than 100 died that were not used in the experiment.

B. 9.

Colony of 150 workers and brood of *L. americanus*; 1 queen killed.

B. 16.

60 workers and brood of *L. americanus*; 3 queens killed. The last one stayed in the nest 17 days; I think she had been adopted.

B. 17b.

300 workers and much brood of *L. claviger*; 1 queen killed.

B. 17c.

25 workers, 3 winged females, 5 males, and cocoons of *L. claviger* var. *subglaber*. 3 queens killed, one of these an alpha queen.

B. 19/1. 20 workers of *L. claviger* and brood; 3 queens killed.

B. 19/2. 20 workers and a few cocoons of *L. americanus*; 3 queens killed.

B. 19/3. 20 workers and a few cocoons of *L. americanus*; 5 queens killed.

B. 19/4. 40 workers and 100 cocoons of *L. americanus*; 7 queens killed.

B. 19/5. 20 workers of *L. americanus* and 200 cocoons; 6 queens killed.

- B. 19/6. 20 workers and 200 cocoons of *L. americanus*; 6 queens killed.  
 B. 19/7. 20 workers and 150 cocoons of *L. americanus*; 6 queens killed.  
 B. 19/8. 12 workers and 100 cocoons of *L. americanus*; 3 queens killed, 1 an alpha.  
 B. 19/10. 30 workers, 7 queens, no brood of *L. nearcticus*; 6 queens killed.  
 B. 19/11. About a dozen workers, 30 cocoons, of *L. nearcticus*; 2 queens killed.  
 B. 19/12. About a dozen workers, 1 male and 30 cocoons of *L. nearcticus*; 1 queen killed.  
 B. 19/14. 30 workers, no brood, of *L. claviger*; two queens killed.  
 B. 19/15. 50 workers, many cocoons of *L. nearcticus*; 1 killed.  
 B. 19/16. 36 workers, many cocoons of *L. brevicornis*. 2 queens killed.  
 B. 19/17. 8 workers and many cocoons of *L. americanus*; 4 queens killed.  
 B. 19/18. 4 workers and many cocoons of *L. americanus*; 3 queens killed.  
 B. 19/19. 6 workers and a few larvæ of *L. americanus*; 2 queens killed.  
 B. 19/20. 30 workers and many cocoons of *L. americanus*; 2 queens killed.  
 B. 19/21. 30 workers and no brood of *L. minutus*; 1 queen killed.  
 B. 19/22. 12 workers and no brood of *L. interjectus*; 1 queen killed.  
 B. 19/23. 25 workers and brood of *L. latipes*; 1 queen killed.

The fact that more queens died in some of the colonies than others has no significance, for in some of them I did not replace the first queen.

We thus have two positive cases of adoption of queens of *L. latipes* by workers of other species of *Lasius* and the five records given above show that *latipes* occurs in mixed colonies in nature. At first thought it might seem that 2 adoptions out of 79 attempts is entirely too small a percentage upon which to base any conclusions whatever regarding the point of temporary parasitism. Yet considering the fact that nests of *L. latipes* are not found abundantly in nature and that the queens are produced in the colonies in large numbers would we expect a larger number of adoptions? It is very doubtful whether even in *L. americanus* 2.5 per cent. of the queens succeed in founding colonies.

Another possible explanation for the mixed colonies, however may be suggested by an observation which I made on September 5. There had been a nuptial flight of *L. americanus* and *L. latipes* and as I was walking through a park reservation not far from the Bussey Institution between five and six o'clock in the evening, I picked up off the ground 30 dealated females of *L. americanus* and 5 dealated beta females of *L. latipes*. As I had but one box with me I placed the queens of both species together and upon returning to the laboratory a few minutes later, dumped them all together in the same nest. After a few

minutes the *americanus* queens were huddled together near a moist sponge I had provided for them but the *latipes* queens, always more restless in confinement, were still running about in the nest. They were continually running over or through the bunch of *americanus* queens and sometimes remained with them for several minutes, yet I never saw the slightest signs of hostility either on the part of the *americanus* or the *latipes* queens. The next morning 3 of the *latipes* queens were dead and two days later the other 2 died, yet I feel quite sure that death was not caused by any hostility on the part of the *americanus* queens. In the same length of time 7 *americanus* queens died, but there have been no more deaths up to the present time. I feel sure that a number of the deaths of the *americanus* queens were due to injuries received when I picked them up off the ground. The fact that the nuptial flight of *latipes* and *americanus* may occur at the same time and that the queens of the two species are not hostile to one another suggests the possibility of a colony being founded in common by queens of the two species. This possibility should be tested by experiment. However, I think temporary parasitism a more plausible explanation of the mixed colonies mentioned above because of the fact that the *latipes* queen is of a more nervous temperament, and even though there were no hostilities between the two queens she would not be satisfied to settle down in a little cell with the phlegmatic *americanus* queen and wait nine or ten months for the appearance of workers. This nervous disposition, however, is exactly suited to running about over the ground until the queen happens to run into a small *Lasius* colony, and when she gets on to the brood she is perfectly satisfied to settle down as is shown by the experiments.

The adoption of the *latipes* queen by the colony of *L. interjectus* may be looked upon as adding weight to one of the explanations quoted above for the occurrence of the two forms of females, namely, that the alpha form may be a hybrid between the beta female and a male *claviger*. Since adoption occurred with *interjectus* it might also be expected to occur with the nearly related *claviger* if enough cases were tried. Again the females of *claviger* and *interjectus* are very similar so that the alpha form

might just as well be a hybrid between *latipes* and *interjectus* as between *latipes* and *claviger*.

LASIUS UMBRATUS VAR. MINUTUS.

One of the quotations given above shows the lack of evidence that the queens of this species are able to found their colonies independently. The lack of such evidence taken together with the fact that the ant is sporadic in its occurrence, that it produces an immense number of the sexual forms and that the females differ from all the other *Lasius* females in being very small, no larger than the largest workers, point to temporary parasitism as a method of colony formation.

On August 12 I came across a large mound nest of this species at the edge of a forest reservation near the Arnold Arboretum. The mound was in the shape of a very broad dome, about eighteen inches high and about three feet across at the base. Judging from the size of the nest, the number of individuals and the way the grass was shot up through the mound the colony must have been several years old. With a trowel I took out about a quart of dirt from the side of the mound and brought it to the laboratory. I found that I had about 150 females, an equal number of males, several hundred workers and many cocoons. As the amount of earth I removed hardly made an impression on the mound the colony must have contained several thousand males and females and a still larger number of workers. Although I collected rather extensively in that region and in a number of other localities around Forest Hills, this is the only colony of *minutus* that I found during the entire summer. In my experiments with this species I used 88 queens in 20 different colonies as follows.

B. 25a.

20 workers, 2 winged queens and brood of *L. americanus*.

B. 25b.

8 workers and many pupæ of *L. americanus*.

B. 25c.

8 workers and many pupæ of *L. americanus*.

B. 25d.

30 workers and many pupæ of *L. americanus*.

B. 28/1. 7 workers, no brood of *L. claviger*.

B. 28/2. 24 workers and a few cocoons of *L. americanus*.

- B. 28/3.* 12 workers, and brood of *L. americanus*.  
*B. 28/4.* 6 workers and a few larvæ and pupæ of *L. americanus*.  
*B. 28/5.* 100 workers, and cocoons of *L. americanus*.  
*B. 28/6.* 100 workers, and cocoons of *L. americanus*.  
*B. 28/7.* 75 workers, 1 winged queen and many ocoons of *L. americanus*.  
*B. 28/8.* 12 workers, no brood of *L. interjectus*.  
*B. 28/9.* 25 workers, and brood of *L. americanus*.  
*B. 28/10.* 25 workers and 5 winged queens of *L. nearcticus*.  
*B. 28/11.* 24 workers, and cocoons of *L. americanus*.  
*B. 28/12.* 100 workers and many cocoons and young larvæ of *L. americanus*.  
*B. 28/13.* 12 workers, and cocoons of *L. americanus*.  
*B. 28/14.* 24 workers, and cocoons of *L. brevicornis*.  
*B. 28/15.* 50 workers, and cocoons of *L. nearcticus*.  
*B. 28/16.* 30 workers and a number of cocoons of *L. americanus*.

The queen of this species is very active and very timid. I did not see her attempt to defend herself in any case but always tried to escape and by her active movements she was usually able to get away from the workers for quite a while. When caught, however, she usually succumbed in a much shorter time than was the case with the other species with which I worked. A few of them died within an hour or so after being placed in, others living for several days. Out of all these experiments I got but one case of adoption. I will give a few notes from that experiment.

B. 25b.

- Aug. 18—3.30 P.M. I place a queen of *L. umbratus* var. *minutus* in a Petri dish with 8 workers and a large number of pupæ of *L. americanus*. The workers attack her; she does not defend herself but tries to escape from them.  
 Aug. 19—9.05 A.M. She is running around by herself. A worker attacks her for a little while but she gets away.  
 Aug. 20—9.30 A.M. She is resting on the cocoons with the workers.  
 Aug. 21—9.00 A.M. The same.  
 11.00 A.M. Still on the cocoons with the workers and seems to be entirely immune from attack. About a dozen callows have hatched.  
 Aug. 22. The same.  
 Aug. 23. The same.  
 Aug. 24. There are about 40 or 50 workers in the nest now. The queen stays with them all the time.  
 Sept. 12. Most of the cocoons have hatched. The queen has been fully adopted.

Although one adoption out of 88 attempts is a small percentage, yet I think the ease with which this queen was adopted is very suggestive, and taken altogether with the facts mentioned above, namely the sporadic occurrence of the species, the very large number of females produced, the small size of the females,

the fact that these females have not been seen in the act of founding a colony and one additional fact which may be mentioned, the mimetic coloration of the females (the color of these females is exactly the same as that of the darker form of *americanus*), I think justifies us in concluding that the queen of this species is in all probability, temporarily parasitic upon the common *L. americanus*.

#### POLYERGUS LUCIDUS.

This shining slave-maker has been studied by Mrs. Treat, McCook, Burill, and Wheeler,<sup>1</sup> and the European form *P. rufescens*, by Huber, Forel, Wasmann and Viehmeyer. It differs from the ants mentioned above in that it is not a temporary but a permanent parasite or slave-maker, the workers making raids upon colonies of *Formica schaufussi* and its varieties *incerta* and *nitidiventris*.

Studies by Forel, Wasmann and Viehmeyer on the European *P. rufescens* tend to show that that form resembles the temporary parasites in that the queens may be adopted by fusca workers. In regard to the founding of colonies by *P. lucidus* Wheeler says:<sup>2</sup> "Several experiments in which I introduced artificially dealated queens of *lucidus* into nests containing *incerta* workers with their brood gave rather conflicting results. In some cases the *lucidus* queens behaved like the *sanguinea* queens under similar conditions to the extent of killing the alien workers, but they paid absolutely no attention to the brood. In other cases they were passive and conciliatory but equally indifferent to the *incerta* cocoons. It will be necessary therefore to study this question further before making definite statements in regard to the methods employed by our American amazons in establishing colonies."

The queens used in the following experiments were obtained on the slope of Blue Hill, August 17, the same date upon which we found the large colony of *F. obscuriventris* mentioned above. The nest was along the side of a little-used roadway. On excavating and bringing it to the laboratory I found the colony to contain about a dozen workers, an equal number of winged

<sup>1</sup> See Wheeler, "Ants, Their Structure, Development and Behavior," pp. 482-487.

<sup>2</sup> "Ants, Their Structure, Development and Behavior," p. 486.

queens, one dealated queen of *P. lucidus*, and about 100 very small workers of *F. incerta* and a number of cocoons. The small number of *lucidus* workers and the comparatively large number of females indicates that many of the workers were probably out on a slavemaking raid at the time.

I tried seven queens with colonies of *F. incerta* and four with *F. schaufussi*. Two out of the seven were clear cases of adoption in which the queens are still living. One of the others I think was without doubt adopted but died later on from injuries received in the first struggles. The two *schaufussi* colonies consisted of very large individuals and each contained a queen. They attacked the *lucidus* queens more fiercely than did the *incertas*, and all four were finally killed, yet in both colonies I saw at times a few of the workers licking the queens and I think it would be possible if enough cases were tried, to secure adoption with *F. schaufussi*, especially if the colonies did not contain queens of their own.

The behavior of the *lucidus* queens was like that of the *obscuriventris* queens in that they did not at first attack the workers but ran about in the nest avoiding them and trying to escape. However, when caught and held by the workers they were not nearly so submissive as were the *obscuriventris* queens and when forced to defend themselves they did so with such vigor and persistence, piercing the head or thorax of the unfortunate workers with their long sickle-shaped mandibles so that a very large number of the *incertas* or *schaufussi* workers were killed. In one of the *schaufussi* colonies the *lucidus* queen killed every one of the fifteen workers, leaving only the *schaufussi* queen. Later on, however, the *lucidus* queen herself died. My results agree with those of Wheeler mentioned above in that I did not see a queen at any time pay the slightest attention to the brood, her behavior being different in this respect from *F. sanguinea*, which, as Wheeler has shown, kills off the workers, takes possession of the brood and frees the first callows from their pupal envelopes. I will give a few notes from the two experiments in which the queens were adopted and are still living.



## B. 23a.

Aug. 18—2.00 P.M. I place a dealated queen of *P. lucidus* in Petri dish with two dozen workers and 8 pupæ of *F. incerta*. They attack her at once. She tries to escape from them and usually manages to do so as she is very vigorous. She does not attack them, and bites them only when she cannot get away.

2.20 P.M. 3 workers holding her, one by a leg and one by an antenna.

4.00 P.M. Still being held by 2 workers.

5.00 P.M. The same.

6.00 P.M. The same.

Aug. 19—8.20 A.M. 3 workers holding her on the sponge. This hostility was continued against the queen until the morning of Aug. 23 when I found her dead.

Aug. 23—1.45 P.M. I place in another *Polyergus* queen. All but one of the cocoons have hatched. Some of the workers escaped, but two have been killed. There are now 15 workers in the nest and 1 of them is injured. The injured one attacks the queen and is soon killed by her. None of the other workers attempt to attack the queen. She runs about in the nest and attempts to escape.

4.00 P.M. 3 workers holding her, 2 by the antennæ and 1 by a leg.

4.30 P.M. 3 workers are licking her.

6.00 P.M. 1 worker is holding her by a leg.

Aug. 24—8.00 A.M. 2 workers are standing by her side; they do not attack her and she does not avoid them.

3.30. 1 of the workers is licking her.

4.00 P.M. 3 workers are licking her. A few minutes later one of them holds her by the tarsus for a while.

Aug. 25—8.00 A.M. The *Polyergus* queen is dead.

2.45 P.M. I place in another queen.

Aug. 26—9.00 A.M. She is standing in the midst of the workers and seems to be entirely uninjured. The workers do not attack her. There are several dead workers in the nest.

11.45 A.M. She moves around with the workers and does not try to avoid them, nor do they avoid her nor show any hostility to her.

Aug. 27—8.00 A.M. The workers are standing all around her; there are 10 left alive.

Sept. 12. I have examined the nest several times every day up to the present time and have never seen her attacked. She has been fully adopted.

## B. 23b.

Aug. 19—11.20 A.M. I place a *Polyergus* queen in one chamber of a nest containing the mother queen, 16 workers and a few larvæ and pupæ taken from a large colony of *F. incerta*. The *Polyergus* queen runs about in the nest trying to escape. The workers are afraid of her and only a few try to attack her. They gather up their pupæ as they would in case of a raid.

1.45 P.M. All but 6 of the workers escape past the cotton plug into the other chamber.

6.00 P.M. The *Polyergus* queen is standing by herself in a corner of the nest. The *incerta* queen and workers are standing in another corner with the brood.

Aug. 20—8.00 A.M. The same.

2.00 P.M. The same.

Aug. 21—10.30 A.M. The same. The *Polyergus* queen kept aloof from the *incertus* all the time until August 24. When I examined the nest at 1.00 o'clock on that day the *Polyergus* queen was running around in the nest but avoiding the *incertus* and they seemed afraid to attack her. About an hour later, however, I found the *incerta* queen dead and the *Polyergus* queen standing near her. I removed the dead queen and examined her. I found four cases where her thorax had been punctured by the sharp mandibles of the *Polyergus* queen. From that time on the *incerta* workers not only did not attack the *Polyergus* queen but they ceased to avoid her, and on the following day I found one of the workers licking her. Since then they have treated her as they treated their own queen before. There are 8 workers in the nest now.

Besides the experiments with the above mentioned ants I tried a few adoption experiments with queens of *F. nepticula*, *F. sanguinea* var. *rubicunda*, and one with a queen of *F. difficilis* var. *consocians*.

The queens of *F. nepticula* were tried with small colonies of *F. inserta*, *F. fusca* var. *subaenescens* and *F. subpolita* var. *neogagates*. The two queens that I tried with *incerta* and *subaenescens* gave negative results. The workers attacked the queens fiercely in each case. The active little queen defended herself, however, by seizing them with her mandibles. The movements made the first few minutes were so rapid that the eye could scarcely follow them. In an hour or so, however, the queen was killed in each nest. The behavior was the same when I placed a queen in with a small colony of *F. subpolita*, but the *subpolita* workers being smaller than those of the other two species were not able to kill the queen so quickly, and after a fierce struggle of a few minutes she escaped from them. Although she was attacked again from time to time the attacks were not so fierce and several times I saw workers licking her; not only that, but her behavior then became more like what Wheeler has described for the queens of *F. consocians* when introduced into a colony of *F. incerta*, more insinuating and conciliatory, and twice I found the *nepticula* queen feeding a *subpolita* worker. Although the two queens which I tried with this *subpolita* colony were both finally killed I think the behavior both on the part of the queen and the workers tends to confirm the conclusions reached by Wheeler in 1906, that *F. nepticula* is a temporary parasite and that its probable host is *F. subpolita*.

The four queens of *F. sanguinea* var. *rubicunda* which I tried with small colonies of *F. subsericea* were not in very good condition as I had kept them too long in confinement without food and with one exception were killed. This one, however, behaved as did those in the experiments described by Wheeler in 1906. She killed four of the eight workers in the nest and after some time took charge of the pupæ. The other four workers remained hostile for about two weeks, after which they adopted her and helped take care of the brood.

The one colony of *incerta* with which I tried a queen of *F. consocians* contained the mother queen, about three dozen workers and several cocoons. I placed the *consocians* queen in with them on August 5 at 4.30 P.M. The introduction of the queen caused very little disturbance. The workers she met nabbed at her and pulled her legs and antennæ a little but not at all violently. Within an hour after being placed in she was fully adopted and was going about feeding the workers by regurgitation. The two queens, *incerta* and *consocians*, lived peacefully side by side. I still have the colony in the laboratory, September 16, and the yellow *consocians* queen seems to be perfectly happy with her strange nest mates. While on a field trip with Professor Wheeler near Colebrook, Conn., July 30 and 31, he found two mixed colonies of *incerta* and *consocians* and has given me the following notes which he made of them:

"Colebrook, Conn., July 30, 1910.

"No. 1. A mixed colony (in the second year) consisting of a *consocians* female and about 100 workers with brood, and a somewhat smaller number of workers of *incerta*. This was under a stone on Mt. Pisgah.

"No. 2. Colebrook, Conn., July 31, 1910. At Beech Hill near the Massachusetts boundary north of Colebrook I found a large and flourishing colony of *F. incerta* containing fully 200 workers and much brood, containing a single *consocians* queen that must have been very recently adopted. This is the largest *incerta* colony in which I have found a *consocians* queen."

The finding of mixed colonies of these two species, *incerta* and *consocians*, near Colebrook, Conn., a number of years ago and subsequent extensive field observations and experiments

is what led to the discovery by Wheeler of the phenomenon of temporary parasitism among ants. At the same time he also showed that temporary parasitism exists in other American ants and predicted that it would be found to exist in certain European ants. These predictions have since been verified by a number of European myrmecologists. The results of the experiments recorded in this paper verify his predictions concerning the queens of *A. tennesseensis*, *L. latipes*, *L. umbratus minutus* and show that *F. obscuriventris* is a temporary parasite upon *F. subsericea* just as he has shown that the European *F. rufa* is parasitic upon the typical *F. fusca*.<sup>1</sup>

A question which will naturally arise in the minds of most people is, "To what extent would it be possible to secure the adoption of non-parasitic queens by workers of different species or even of different colonies of the same species?" Much light would be thrown on the whole subject if an extensive series of experiments with such queens should be conducted, and in the future I hope to be able to perform such experiments. Also, the logician will say that it should not only be proved that queens that are supposed to be temporary parasites may be adopted by workers of another species but it should also be proved that such queens are incapable of founding colonies unaided. That such is the case with some of the queens experimented upon we have only such negative evidence as I have given above, and positive evidence, one way or the other, can be obtained only by an extensive series of careful experiments. However, positive evidence that any of the queens given above as temporary parasites are able to establish colonies independently would not necessarily prove that they may not also be in part temporarily parasitic upon some other species. It is more than likely that a very large number, perhaps most of the ants are in some stage of development toward parasitism. For instance, the above experiments show that the queens of *F. obscuriventris* are not so easily adopted as those of *F. consocians* but much more easily than those of *F. nepticula* or of *A. tennesseensis*. Wheeler has shown that the first step toward both temporary and permanent parasitism from the primitive independent type of colony for-

<sup>1</sup>"Observations on some European Ants," 1909.

mation is the facultative adoption of the queen by workers of the same species, the second the obligatory adoption of the queen by workers of the same species, and third the obligatory adoption of the queen by workers of another species. Perhaps the last species in which one would look for traces of even the first steps toward parasitism would be our dominant species *L. niger* var. *americanus*, since it is well known that the queens of this species are able to establish colonies independently. Workers from one colony of this species are always very hostile to those belonging to another colony and still more so towards queens from another colony, yet, out of eight attempts I succeeded in getting one young fertilized and dealated queen adopted by a colony of *L. americanus* consisting of about three dozen workers, six cocoons and a number of very small larvæ. It is therefore very likely that many of the queens of *americanus* establish their colonies with the aid of workers either of the same or of a different colony. Thus we see that even in our most dominant species we may find the first two steps toward parasitism. It is easily seen, therefore, that there is still a vast amount of work to be done before the last word can be said upon the interrelations of the different species of ants.

In conclusion I wish to thank Professor W. M. Wheeler, under whose direction the work was done, for his many helpful suggestions while the experiments were being conducted and for reviewing my manuscript.<sup>1</sup>

<sup>1</sup> The colonies containing the adopted queens were left at the Bussey Institution and Mr. J. W. Chapman, who was kind enough to care for them, wrote me on November 25, that in each case the adopted queen was treated just as though she were the rightful queen, so that there is no question but that the adoption was complete.